

Original Research Article

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Yield and Nutrient Losses Due to Weeds in Prominent Cropping Sequences under Mid Hills of Himachal Pradesh, India

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ABSTRACT

The present study was carried out in a continuing experiment at the Bhadiarkhar farm of the CSK HPKV. Eight cropping sequences [C₁- 'rice – wheat', C₂- 'rice – pea – summer squash', C₃- 'okra – radish – onion', C₄- 'turmeric – pea – summer squash', C₅- 'rice – lettuce – potato', C₆- 'rice – palak – cucumber', C₇- 'rice – broccoli – radish', C₈- 'colocasia – pea + coriander'] were evaluated during 2016-17. There were 24 weed species which invaded different cropping systems. During *kharif*, *Ageratum sp.* (28%), *Cynodon dactylon* (20%) and *Commelina benghalensis* (19%) were the predominant weeds. In *rabi*, *Phalaris minor* (63%) was the most dominating weed followed by *Coronopus didymus* (10%) and *Spergulla arvensis* (6%). In *kharif*, weed flora was more diverse in C₃, C₄ and C₈ i.e. okra, turmeric and colocasia based sequences, respectively and weed diversity was lower in rice-based sequences. In *rabi*, highest diversity of weed species was in rice-wheat sequence. C₈ had highest RGEY among all the crop sequences. Weeds inflicted huge yield losses ranging from 30.6 in C₁ to 59.2% in C₆. N depletion by weeds ranged from 16.2 in C₆ to 48.5 kg/ha/annum in C₃, P from 3.1 in C₅ to 8.1 kg/ha/annum in C₃ and K from 4.8 in C₆ to 13.2 kg/ha/annum in C₃.

Keywords

Cropping systems,
Weed diversity,
Nutrient losses,
Yield losses

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Introduction

Rice- wheat is the prominent cropping sequence of mid hills of Himachal Pradesh. Despite enormous growth of rice-wheat system, reports of stagnation in the productivity, with possible decline in production in future, have raised doubts on its sustainability (Ramanjaneyulu *et al.*, 2006). Weed infestation is a major obstacle in productivity enhancement in mid hills of Himachal Pradesh. Weeds can reduce the production of rice by 10-100% and wheat by

10-60% (Rao *et al.*, 2014; Yaduraju *et al.*, 2015). Farmers in the region cannot make the best use of fertile land, plentiful water supplies and abundant plant genetic resources, despite climatic conditions that favour cultivation of several crops such as rice, wheat, maize, potato and other vegetables like okra, radish and colocasia.

Controlling weeds satisfactorily increases the cost of cultivation of the crop as well as deplete resource base (Buriro *et al.*, 2003). Most of farmers of Himachal Pradesh are

small, marginal and are unable to bear the heavy costs associated in carrying out weed management operations. Chemical weed control creates many problems such as development of herbicide resistant weeds, shifting weed flora and environmental pollution. Different planting and harvest dates among crops can prevent or reduce weed establishment or seed production. Furthermore, crop diversity can improve crop growth (Kirkegaard and Hunt, 2010), thereby increasing crop competitiveness and tolerance to weeds (Anderson, 2011). Rotations composed of a diversity of crops with different life cycles are a sound option to manage weeds and critical component of integrated weed management (Colbach *et al.*, 2014). To ensure safe guard against environmental pollution and to reduce chances of shifting of weed flora and development of herbicide resistant weeds, crop rotations which allow minimum weed infestation and yield losses, appear to have great importance. Therefore, studying weed diversity in diversified cropping system and associated yield and nutrient losses have immense significance.

Materials and Methods

The present study was carried out in a continuing experiment at the Bhadiarkhar farm of the university. The experiment was started in *kharif* 2014. Eight cropping sequences [C₁- 'rice – wheat', C₂- 'rice – pea – summer squash', C₃- 'okra – radish – onion', C₄- 'turmeric – pea – summer squash', C₅- 'rice – lettuce – potato', C₆- 'rice – palak – cucumber', C₇- 'rice – broccoli – radish', C₈- 'colocasia – pea + coriander'] were evaluated during 2016-17 in RBD with four replications. The crops were raised in accordance with the recommended package of practices for the region. Gross plot size was 26.4 m² and a part of plot (2m × 2m) was left weedy (without herbicide spray or hand weeding). The

economical yield of crops was taken from net plot and was converted into t/ha. The yield from weedy plot (2m × 2m) was recorded separately and also converted to t/ha. Yield losses were computed by comparing per hectare yield of the main and weedy plot.

In order to draw a valid conclusion the yield of individual crop was converted to RGEY (rice grain equivalent yield) using formula:

RGEY (t/ha) = Economical yield of a crop e.g. wheat (t/ha) X [Price (₹ /kg) of same crop e.g. wheat / Price (₹ /kg) of rice]

The RGEY of component crops in each system were added to get the total RGEY of the cropping systems.

Species-wise weed count and samples for weed dry weight were taken at monthly interval from 25 cm x 25 cm quadrat/area at two sites in each main plot. The weed count so obtained was converted into No./square metre by multiplying the mean count of the weed with factor 16. These samples for dry weight were oven dried at a temperature of 70°C till constant weight. The dry matter thus recorded was also multiplied by the factor 16 to obtain weed dry weight/square metre. Weed samples collected at termination of both seasons were oven dried, ground and analysed for nitrogen (Jackson, 1973), phosphorus (Jackson, 1973) and potassium (Black, 1965). The uptake of N, P and K was calculated by multiplying nutrient content with corresponding dry weight and expressed in kg/ha.

The data on weed dry weight and crop yield were subjected to statistical analysis using the techniques of analysis of variance as described by Gomez and Gomez (1984) and compared at 5 percent level of significance. Weed dry weight data showed variation, therefore, were analyzed after subjecting the original data to square root transformation ($\sqrt{x + 0.5}$).

Results and Discussion

Surveillance and distribution of weed species

Total of 24 weed species were found associated in different cropping sequences. The weed flora in *rabi* was more diverse than in *kharif* (Fig. 1). In *rabi*, *Phalaris minor* was the most dominating weed contributing 63% to total weed flora followed by *Coronopus didymus* (10%), *Spergulla arvensis* (6%), *Ageratum sp.* (4%), *Trifolium repens* (3%), *Cynodon dactylon* (3%) and *Polygonum sp.* (4%). Other weeds as a whole made up 7%.

Ageratum was the most dominant weed in *kharif*. It contributed about 28% of total weed flora. *Cynodon dactylon* and *Commelina benghalensis* were next in dominance constituting 20% and 19% of total weed flora, respectively. *Brassica sp.* and *Monochoria vaginalis* were other important weeds contributing 11 and 10%, respectively to total weed flora. *Cyprus sp.* and other weeds each constituted 6% to total *kharif* weed flora.

Weed dry weight

The dry matter accumulation during *kharif* increased with time (Table 1). Maximum dry weight under the cropping systems was at end of season i.e. during October. There were contrasting differences among the cropping systems in influencing dry weight accumulation during *kharif*.

Differences in dry weight accumulation among the cropping systems were very much clear in *rabi*. The dry matter accumulation during *rabi* decreased with time due to imposition of treatment but, after March dry weight increased many folds. The maximum dry matter accumulation was recorded at the termination of season during April and May. Significantly higher dry weight was recorded

in 'rice-wheat', 'rice-pea-summer squash' and 'colocasia-pea + coriander'. In *kharif* dry weed weight during July and October significantly varied under the cropping systems. Similarly cropping system brought significant variation in the dry weight of *rabi* weeds during March and April.

Average dry weight of *kharif* and *rabi* weeds significantly varied among different cropping systems (Table 1). In *kharif* highest average dry weight was in 'okra-radish-onion' being at par with 'turmeric-pea-summer squash' and 'colocasia-pea + coriander'. Lowest dry weight was recorded in 'rice-pea-summer squash' being at par with 'rice-lettuce-potato', 'rice-broccoli-radish', 'rice-wheat' and 'rice-palak-cucumber'. This concludes that rice-based cropping systems had lower weed dry weight might be due to continuous submergence and were statistically at par with each other. The other upland cropping systems had higher weed dry weight being statistically at par with each other.

In *rabi*, average dry weight was highest in 'colocasia-pea + coriander' being at par with 'rice-wheat', 'rice-pea-summer squash' and 'okra-radish-onion'. Minimum dry weight was in 'rice-palak-cucumber' being at par with 'turmeric-pea-summer squash', 'rice-lettuce-potato' and 'rice-broccoli-radish'.

Rice grain equivalent yield

The data on yield of the main product of individual crop and RGEY have been summarized in Table 2. 'Colocasia – pea + coriander' resulted in significantly higher RGEY compared to other cropping systems due to higher tonnage of colocasia. This system was followed by 'rice – lettuce – potato' and 'okra – radish – onion'. The higher yield in these systems was owed to higher tonnage of lettuce and potato and radish and onion, respectively.

Table.1 Dry weight (g/m²) of weeds in different cropping systems

Cropping system	rabi							kharif				
	DEC	JAN	FEB	MARCH	APRIL	MAY	Mean	JULY	AUG	SEP	OCT	Mean
C ₁	7.4	5.8	5.8	5.6	12.9	7.7	8.1	4.7	8.6	7.0	6.2	6.9
	(62)	(34)	(33)	(32)	(167)	(65)	(66)	(22)	(75)	(49)	(41)	(47)
C ₂	8.2	6.1	6.0	6.2	9.8	10.1	8.0	5.5	7.8	5.1	5.4	6.1
	(72)	(37)	(36)	(39)	(98)	(105)	(65)	(31)	(62)	(27)	(29)	(37)
C ₃	7.8	5.7	5.0	5.7	6.8	11.4	7.7	8.1	8.2	9.4	12.6	9.8
	(61)	(32)	(25)	(33)	(52)	(174)	(63)	(66)	(72)	(89)	(162)	(97)
C ₄	6.2	5.9	5.8	5.7	6.1	8.1	6.5	7.3	7.7	7.9	10.2	8.4
	(40)	(34)	(36)	(33)	(38)	(69)	(42)	(54)	(62)	(63)	(106)	(71)
C ₅	7.0	6.5	4.6	3.7	8.4	8.6	6.9	5.3	7.2	6.1	5.6	6.2
	(52)	(43)	(21)	(13)	(77)	(78)	(47)	(29)	(53)	(39)	(33)	(39)
C ₆	6.7	5.9	4.6	5.1	6.6	7.3	6.2	5.8	8.2	8.1	4.8	7.2
	(45)	(35)	(21)	(26)	(45)	(53)	(38)	(34)	(69)	(82)	(26)	(53)
C ₇	8.1	6.8	6.6	0.7	5.3	9.6	6.9	6.7	7.0	5.8	5.2	6.3
	(70)	(46)	(43)	(0)	(29)	(94)	(47)	(45)	(49)	(34)	(27)	(39)
C ₈	9.5	6.7	6.6	6.1	13.0	10.1	9.1	7.1	7.2	8.0	11.0	8.6
	(92)	(45)	(45)	(37)	(178)	(102)	(83)	(51)	(51)	(64)	(134)	(75)
SEm±	0.80	0.34	0.51	0.43	1.19	1.50	0.59	0.55	0.70	1.00	1.09	0.50
LSD (P=0.05)	NS	NS	NS	1.3	3.5	NS	1.7	1.6	NS	NS	3.2	1.5

* Figures in the parentheses are the means of original values. Data transformed to square root transformation ($\sqrt{x+0.5}$)

C₁- 'rice – wheat', C₂- 'rice – pea – summer squash', C₃- 'okra – radish – onion', C₄- 'turmeric – pea – summer squash', C₅- 'rice – lettuce – potato', C₆- 'rice – Palak – cucumber', C₇- 'rice – broccoli – radish', C₈- 'colocasia – pea + coriander'

Table.2 Effect of crop sequences on Rice Grain Equivalent Yield (RGEY)

Cropping system	Yield main product (t/ha)				RGEY (t/ha)	Energy output MJ/ha	
	kharif	Rabi I	intercrop	Rabi II			
C ₁	'Rice – wheat'	3.88	4.71	-	-	9.6	250092
C ₂	'Rice – pea – summer squash'	3.60	2.65	-	3.45	13.8	166520
C ₃	'Okra – radish - onion'	0.95	8.09	-	7.03	17.1	112250
C ₄	'Turmeric – pea – summer squash'	2.72	2.59	-	2.63	14.4	86473
C ₅	'Rice – lettuce – potato'	3.88	5.30	-	7.62	19.1	162360
C ₆	'Rice – palak – cucumber'	3.31	2.66	-	3.58	11.5	114695
C ₇	'Rice – broccoli – radish'	2.84	1.59	-	8.63	12.7	152775
C ₈	'Colocasia – pea + coriander'	8.14	4.64	0.96	-	24.5	92508
	LSD(P=0.05)					3.6	20021

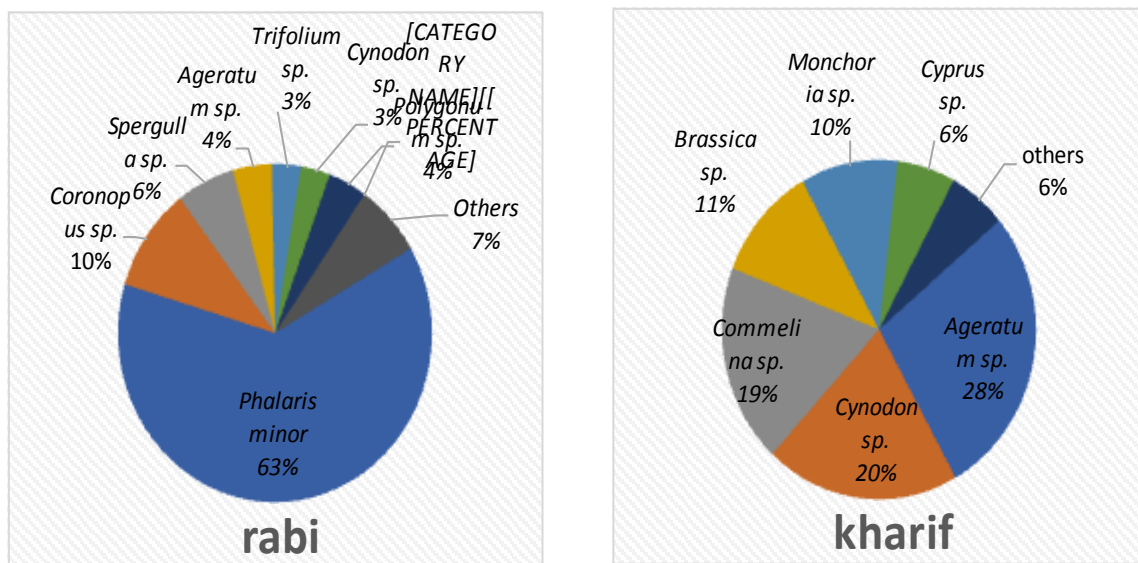
Table.3 Cropping systems influence on NPK depletion (kg/ha) by weeds during *rabi* and *kharif*

Cropping system	Rabi			Kharif			Total Rabi + Kharif		
	N	P	K	N	P	K	N	P	K
C ₁ 'Rice – wheat'	11.2	3.0	2.0	9.7	1.8	3.8	20.9	4.8	5.8
C ₂ 'Rice – pea – summer squash'	8.8	1.7	2.4	9.6	1.8	3.8	18.4	3.5	6.2
C ₃ 'Okra– radish'– onion'	39.4	6.3	9.5	9.1	1.7	3.7	48.5	8.1	13.2
C ₄ 'Turmeric – pea – summer squash'	16.7	4.0	3.6	5.5	1.1	2.4	22.2	5.1	6.0
C ₅ 'Rice – lettuce – potato'	10.5	1.8	3.2	7.0	1.3	2.8	17.5	3.1	5.9
C ₆ 'Rice – palak – cucumber'	10.6	2.3	2.6	5.6	1.0	2.2	16.2	3.3	4.8
C ₇ 'Rice – broccoli – radish'	13.5	2.3	4.1	7.1	1.3	2.7	20.6	3.5	6.9
C ₈ 'Colocasia – pea + coriander'	16.2	4.1	3.2	12.0	2.2	4.9	28.2	6.3	8.0
LSD (P=0.05)	6.8	1.4	1.6	4.3	NS	NS	7.6	1.5	2.2

Table.4 Yield losses (%) due to weeds

Cropping system	Losses (%)				
	Kharif	Rabi I	Intercrop	Rabi II	Total
C ₁ 'Rice – wheat'	34.5	26.5	-	-	30.6
C ₂ 'Rice – pea – summer squash'	34.6	38.6	-	28.8	35.3
C ₃ 'Okra – radish - onion'	49.9	35.4	-	50.0	43.8
C ₄ 'Turmeric – pea – summer squash'	46.0	34.4	-	31.3	37.8
C ₅ 'Rice – lettuce – potato'	31.6	69.1	-	9.6	33.8
C ₆ 'Rice – palak – cucumber'	30.2	70.7	-	75.1	59.2
C ₇ 'Rice – broccoli – radish'	23.1	7.5	-	47.9	37.9
C ₈ 'Colocasia – pea + coriander'	60.0	41.5	55.7	-	53.8

Fig.1 Proportion of weeds during *kharif* and *rabi*



The other cropping systems viz. 'turmeric – pea – summer squash', 'rice - pea – summer squash', 'rice – broccoli – radish' and 'rice – palak – cucumber' had higher yield than 'rice – wheat'. The data on RGEY shows that its value increased with increase in cropping intensity. Crop intensification with vegetables in systems gave higher RGEY. Higher value of RGEY was obtained from a system of 300 percent cropping intensity, 'colocasia – pea + coriander' while minimum value was recorded from a system having 200 per cent cropping intensity 'rice – wheat'. Colocasia resulted in highest RGEY followed by potato and onion among all crops in various cropping systems.

Rice based vegetable cropping systems resulted in higher rice grain equivalent yield compared to cereal-cereal cropping system. Prasad *et al.*, (2013) reported higher RGEY when 'rice-wheat' cropping system was diversified and vegetable crops were included in system.

Highest energy output of the main product was observed in 'rice – wheat' system.

Nutrient losses by weeds

The estimates on nutrient losses by weeds are given in Table 3. The nutrient losses due to weeds were huge under the cropping systems. Nitrogen and phosphorous depletion by weeds was higher in *rabi* compared to *kharif*. Highest depletion of nutrients was seen in 'okra– radish– onion', followed by 'colocasia - pea + coriander' due to more growth of weeds. High nutrient depletion by weeds from same location was also reported by Suresha *et al.*, (2015) in maize based sequences.

Total yearly NPK depletion by weeds in the other alternative cropping systems was either equal or lower than the conventional 'rice-wheat' cropping system.

Yield losses by weeds

The yield losses estimate due to weeds in the individual crop and combined of the cropping system as a whole are summarized in Table 4. Yield losses in crops due to weeds were computed by comparing per hectare yield of the treatment and weedy situation in each plot. Weeds caused huge yield losses in different cropping systems, ranging from 31 (rice-wheat) to 59% (rice – palak – cucumber). Yield losses in 'rice – wheat' sequence were 34.5 and 26.5%, respectively. Similar results were reported by Yadav *et al.*, (1998) in wheat, when grown in sequence. Yield losses in all the new cropping systems were higher than traditional 'rice-wheat' cropping system. Yield of green leaf crops was highly affected due to weeds followed by vegetable crops. Highest losses were observed in cucumber where weeds resulted in 75% losses in yield followed by palak with 71% losses in yield.

The present investigation inferred that weeds are dynamic in nature and they inflict huge yield (31-59%) and nutrient (16.2-48.5 kg N, 3.1-8.1 kg P and 4.8-13.2 kg K per hectare) losses, thereby depriving the crops for want of nutrients. Therefore, careful adoption of crops and cropping systems is needed for successful management of prevalent weed species.

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